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OXIDANT AIR POLLUTION AND WORK PERFORMANCE OF CITRUS HARVEST LABOR

by

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FOREWORD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our Nation's population.

The Health Effects Research Laboratory, Research Triangle Park, conducts a coordinated environmental health research program in toxicology, epidemiology, and clinical studies using human volunteer subjects. These studies address problems in air pollution, non-ionizing radiation, environmental carcinogenesis and the toxicology of pesticides as well as other chemical pollutants. The Laboratory develops and revises air quality criteria documents on pollutants for which national ambient air quality standards exist or are proposed, provides the data for registration of new pesticides or proposed suspension of those already in use, conducts research on hazardous and toxic materials, and is preparing the health basis for non-ionizing radiation standards. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of health care and surveillance of persons having suffered imminent and substantial endangerment of their health.

The economic impact on individuals from exposure to high oxidant concentrations may be reflected in many forms. This study attempts to measure in economic terms one of these forms - the effect on worker productivity. The results of this study indicated that the average income citrus workers in Southern California was reduced by approximately two percent when working in areas where oxidant concentrations were high. Considerable differences in performance levels of workers were noted when exposed to similar environmental conditions. This report represents the first attempt to document the economic cost of reduced productivity, a very important and frequently neglected social cost of air pollution.

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PREFACE

This project was initiated in the summer of 1975 while the authors'were at the University of California, Riverside. Dr. Donald Gillette of the Health Effects Research Laboratory of the U.S. Environmental Protection Agency originally suggested the research. Professor Lester Lave of Carnegie-Mellon University, Professor Jon Nelson of The Pennsylvania State University, Professor Wallace Gates of Princeton University, the Resource Economics Group at the University of New Mexico, and Professors Ralph d' Arge, Robert Rowe, and Todd Sandler of the University of Wyoming have all provided helpful comments. Personnel of the Statewide Air Pollution Research Center of the University of California, particularly Dr. C. Ray Thompson, have under rather trying circumstances, greatly expedited administrative details of the project. Computational assistance has been provided by the University of Wyoming Computer Center.

ABSTRACT

This project assesses the effect of photochemical oxidants on the work performance of twelve individual citrus pickers in the South Coast Air Basin of southern California. A model of the picker's decision problem is constructed in which oxidants influence the individual's picking earnings and leisure-time via a short-term and reversible morbidity effect. Circumstances are specified under which this effect can be interpreted as the additional earnings the individual would have to receive in the presence of oxidants in order to make him indifferent to the presence of oxidants. This Hicksian compensating surplus is estimated separately for each of twelve individuals. In terms of absolute dollar magnitudes, compensating surpluses appear to range from less than twenty dollars to nearly two hundred dollars over an entire calendar year, given the piece-work wage rate scales and the levels of air pollution prevailing in the South Coast Air Basin during 1973 and 1974. As a percentage of what individual earnings would have been in the absence of air pollution, the dollar magnitudes range from three-tenths of one percent to nine percent, The average is about two percent. All estimates of the compensating surplus are conditional upon the individual not adjusting the hours he picks in response to air pollution,

Estimates give fairly strong support to the hypothesis that air pollution impact, measured in terms of the compensating surplus, tends to increase with Increasing numbers of hours worked.

No tendency was found for the individual to substitute leisure-time for work-effort as ambient oxidant levels increased. However, the procedures employed to estimate this relationship could have biased the results.

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Chapter 1

INTRODUCTION

Upon having acquired some familiarity with the epidemiological literature reviews attempting to document the covariation of health effects and air pollution, one is struck by the frequent inability of these reviews to discover a substantial number of consistent findings for the effects thought to be caused by any one pollutant. Various reasons are typically advanced for this lack of consistency: inadequate characterization of the pollutants; the use of noncomparable, and sometimes questionable, estimating techniques; failure to account for other environmental influences and self-induced health stresses; failure to distinguish between pollution levels at work and at home; lack of attention to the difference between indoor and outdoor pollution; and other factors.[1] Nowhere in this refrain is it pointed out that epidemiology lacks an analytical framework in which the objects of study, human beings, are viewed as being capable of choice. In particular, the health effects of air pollution are usually treated as being absolute, even though all epidemiological findings are statistical inferences drawn from a sample of individuals with minds of their own. Basically, a set of inputs, including air pollution is posited to exist and these inputs are considered to be combined, on grounds of some a priori investigator knowledge about exogenously determined physical and biological associations, to produce an output, an observed health effect. The epidemiological literature generally fails to recognize that to the extent health effects are subject to fixed economic and non-economic constraints, these effects have to be measured on norms endogenous to the individual human being. Attempts to explain the etiology of observed health effects must recognize that these individuals use different input mixes and magnitudes because: (1) they face different sets of relative prices for various combinations of preventive and ameliorative health care; (2) they have different biological endowments, measured and nonmeasured; and (3) they succeed to varying degrees, in the presence of uncertainty, in maximizing utility. Most epidemiological effort accounts for only the second of these considerations, even though remedial measures to combat pollution-induced health effects may differ, depending on whether the etiology of the health effects depends on economic or biological factors. One purpose of this study is to provide an example, albeit an incomplete example, of how microeconomic analysis permits the introduction of the first consideration into an empirical study fundamentally epidemiological in emphasis. No serious attempt is made, however, to show how the analytical framework of the study might be generalized to encompass a broad variety of epidemiological problems. Nevertheless, although no effort will be made to do so here, it will be fairly apparent that the analytical framework is easily generalized to account for the third consideration. The typical epidemiological study of the health effects of air pollution might capture the health effects that lie in people's stars; it fails to capture the health effects that lie in people themselves.[2]

A second and perhaps less controversial motivation for this study is to provide and apply an analytical framework for assessing the economic effects of environmental pollution upon the performance of inputs, particularly labor inputs, in production processes. Nearly all studies of the economic effects of environmental pollution view changes in relative market prices as being demand-induced.[3] Constant relative unit supply prices as between and among outputs are assumed. However, any change in process productivity necessarily alters the price the producer must receive in order to be willing to supply a given quantity of an output good. These productivity changes therefore also constitute a source of change in output market prices. Failure to consider the impact of pollution upon supply means that an important facet of the total economic effect of environmental pollution is being neglected. Although the present study is limited to estimating the effect of air pollution upon worker performance, it does provide an example of a necessary step in any attempt to ascertain the ultimate economic impact upon the market price of the outputs the workers cooperate in producing.

Those studies of the economic effects of environmental pollution upon inputs that have been performed are known as materials damage studies.[4] They have two distinguishing common characteristics. First, they focus entirely upon specific inputs without devoting attention to the manner in which the inputs are involved in a production process. This study appears to be the first dealing with a particular input that explicitly accounts for the producer's decision problem.

A second distinguishing characteristic of the materials damage studies is their fixation on nonhuman inputs. Except for a few rather rough efforts employing highly aggregated data, the economics of the effects of environmental pollution upon worker performance has been left undone. Perhaps the reason is that data drawn from the performances of individual workers doing jobs requiring substantial physical exertion in an occasionally highly polluted environment have been lacking. Data of this sort were available for this study.

Finally,. there currently is virtually no evidence bearing upon the economic effects of photochemical smog.[5] In spite of this, quite stringent ambient air quality standards have been adopted for the various chemical precursors of smog as well as for the mixture that results from atmospheric transformation processes. Although it cannot be expected that the effects established in these pages constitute a large portion of the total negative economic effects of photochemical smog, the results provide defensible evidence that these effects do in fact exist.

In succeeding chapters, the effect of photochemical smog upon the work performance of citrus workers is investigated, The next chapter describes the analytically relevant features of the market setting for the empirical efforts reported in the fifth and the sixth chapters. A third chapter is both a summary of the data base available for the study and a commentary on the deficiencies of this data base with respect to the analytical model presented in the fourth chapter. A final chapter summarizes the study, point6 out its limitations, and suggests how more information might be gleaned from the same data base,

Footnotes: Chapter 1

1. For an extension of this list, see Commission on Natural Resources (1975) 58-169.

2. A recent paper by Smith (1975) tends to support the argument of this paragraph. In applying the Ramsey tests for specification error to some thirty-six epidemiological studies on air pollution and mortality, Smith found that not a single one of the studies met the Ramsey tests for the absence of this error!

3. The studies used by Waddell (1974) are almost entirely of this sort.

4. Waddell (1974) lists several such studies.

5. The only really careful study available appears to be Nelson (1975).

Chapter 2

THE EMPIRICAL SETTING

The Setting. This study deals with the men and women whose primary occupation is the harvesting of citrus fruit in the South Coast Air Basin of southern California. The object of the study is to ascertain whether their work performance is influenced by the presence of photochemical smog. The occupation of citrus harvesting has the ease of entry and exit, the geographical and numerical scope, and the absence of idiosyncratic (i.e., heterogeneous,.highly differentiated, task-specific skills enabling the current occupant to possess a degree of monopolistic advantage) characteristics that Doeringer and Piore (1971) term the secondary labor market. Harvesting operations in citrus groves are highly labor-intensive activities for which there at present exist no economic substitutes for hand-labor. A substantial number of workers choose to be employed on a year-round basis and are thus exposed to varying air pollution levels over the year. Since the citrus harvest occurs in both high and low smog months, many individuals work during periods of relatively low and relatively high smog levels.

Except for backyard citrus trees, citrus is a crop which even in the smallest commercial groves has harvest labor requirements well in excess of any labor supply the family of the owner is'likely to be able to provide.[1] Rosedale and Mamer (1974, p. 11), in a study of harvest operations in Ventura County, the center of California's lemon industry, indicate that from 1966 through 1972 eighty-five to ninety percent of harvest costs were direct labor costs. In an earlier study of the Ventura County lemon industry Smith, et. al, (1965, p. 4) state that ". ..all labor and material costs for *lemon production on the tree averaged eighty-five cents per field box." Forty-five cents of this sum was picking cost.

There appears to have been very little change in citrus harvest labor productivity over the years. Our data indicate that the representative worker picks about 1900 pounds of lemons and 3000 pounds of oranges per eight-hour work day. Fellows (1929, p. 71) indicates that in 1929 those rates corresponded to 1750 pounds of lemons and 3000 pounds of oranges, Although mechanical harvesting aids and systems do exist, the U.S. Census of Agriculture (1973, pp. 6, 29) shows that, in the 1968-69 season, of 764 reporting California lemon groweis who harvested nearly 700 million pounds of lemons, only six growers, harvesting a total of less than five million pounds of lemons, used harvesting machines. Similarly, of 1969 California orange growers reporting slightly more than two billion pounds of oranges harvested, only sixteen growers, whose aggregate harvest was 11.7 million pounds of oranges, employed machines for picking. For both technological and economic reasons, it would appear that picking labor is an integral and necessary part of the California citrus industry.

Harvest operations in the California citrus industry are typically organized around large packing-houses that are either privately owned and usually specialize solely in harvesting, packing, and marketing, or are grower cooperatives (e.g., Sunkist Growers) who participate in all facets of citrus production. Many growers turn their harvest operations almost entirely over to the packing-houses, permitting picking policies and the sequence of picks across different owners' groves to be established by the packing-house management. This management is said to have a general idea at any particular time of the sequence in which groves are to be picked, but the initially selected sequence is subject to alteration according to weather conditions, the rate at which fruit in particular groves is ripening and growing, and other factors. Orange picking activities are said to be somewhat less subject to plan alterations of this sort than are lemons. This perhaps is due to the fact that at least some lemons are normally picked every week of the year, while the picking times for orange varieties are more limited in the choice of harvest dates. The marketing of oranges appears to be similarly concentrated in time. Table 2.1 below gives the relevant picking and marketing calendar time intervals for southern California lemons and oranges. The geographical area to which the table refers roughly corresponds to the climates prevailing over the south Coast Air Basin..

Table 2.1

Annual Harvesting and Marketing Cycles for Southern California Citrus

	Lemons	Oranges: Early, Midseason, Navels	Oranges: Valencias
Full bloom dates	March 5-Dec. 30	March S-March 30	March 5-March 30
Begin harvest	Aug. 1	Nov. 20	March 10
Most active harvest	Jan. U-July 15	Dec. 15-May 15	May 10-Oct. 25
Begin marketing	Aug. 1	Nov. 25	March 15
Most active marketing	March-July 15	Dec. 20-May 20	May 15-Nov. 1
End marketing	July 31	June 15	Dec. 20

Source: Statistical Report Service (1975, pp. 40-44).

Within the range of prices that have prevailed since World War II, the consumer demand for fresh citrus fruit as well as processed citrus fruit is thought to be relatively price inelastic.[2] However, given that' citrus fruit is often stored for as long as six months with only moderate spoilage, an individual grower is unlikely to exercise meaningful influence upon market price via his harvesting and marketing decisions. A further implication is that the size of the crop and factors such as weather, rather than market price, will be the primary influences upon the quantity and temporal distribution of harvest labor requirements, assuming, of course, that the price and availability of labor does not exhibit substantial seasonal fluctuations. Interviews with packinghouse managers have confirmed that market prices expected during the next one to six months in a particular harvest year have little or no influence upon the choice of harvest dates although, in exceptional circumstances, expected prices may determine whether the season's fruit in a particular grove will be harvested at all.[3] In effect, therefore, over a falrly wide range of piece-work wage rates for harvest labor during a particular growing season, there will be near-zero covariation between this wage rate and the number of harvest labor man-hours expended in a particular grove. The man-hours expended will primarily be a function of the amount of fruit in the grove.

The individual picker is part of a picking crew that, according to the stage in the picking cycle, may be as small as ten people and as high as forty people. A typical size appears to be about thirty people. The crew is supervised by a foreman who is paid in proportion to the amount of fruit his crew picks. This foreman is responsible for getting the pickers and equipment to the grove to be picked and for maintaining his crew at the desired size. Once in the grove, the foreman tries to assure that the fruit is picked in accordance with the specified conditions. He also maintains a record of the amount of fruit picked by each picker.

Over each crew foreman is a salaried field superintendent. This superintendent answers to the general manager of the packing-house or growers' cooperative and is responsible for the over-all operation and coordination of harvesting and grove maintenance activities within and among groves and growers. In the great preponderance of situations where the piece-work wage rate for pickers varies with the relative difficulty of picking conditions, it is he, prior to the entrance of pickers into the grove, who estimates the relative difficulty of the picking opportunity and thereby establishes the piece-work rate to apply to the particular grove. In the words of one packing-house manager, the base rate that is adjusted according to the degree of picking difficulty is established in accordance with "prevailing market conditions."

Frequently, the responsibility for securing a suitable labor supply for harvesting purposes is transferred from the packing-house or cooperative to a labor contractor,' a specialist in the recruitment and supervision of citrus workers. Crew foremen are then employees of the contractor rather than the packing-house or cooperative, although the actual performance of crews will continue to be monitored by a field superintendent, Pickers are paid for their production performance by the contractor and it is he who sets the piece-work wage rate for each grove. The contractor, in effect, assumes the functions and associated risks of picker recruitment, supervision, payment, and provision of whatever picker support facilities are standard. In return, the contractor is guaranteed a certain rate of compensation. The labor contractors involved in the present study all appear to have had long experience in their business and to have rather large operations. They have made the flow of their business regular and routine and depend upon established customers and a large number of workers who have been previously employed by them and to whom they can offer fairly regular employment.

The Mechanics of Picking Citrus Fruit. Actual picking procedures for lemons and for oranges have many common features but they also differ in several important respects. The differences tend to be due mainly to the fact that during any one season the fruit in a lemon grove does not mature for picking purposes at the same time but instead is distributed over much of the year. This means that any single grove might be picked as many as four times in a given season. During the first three picks, only the fruit that is "up to size" is picked. In order to ascertain whether a given piece of fruit is of picking size, the picker must manipulate a measuring device. In addition, as he must also do when picking oranges, he must avoid damaging the fruit quality by leaving long stems, cutting the point at which the stem is attached to the fruit, or pulling the fruit off the tree. Only during the terminal or "strip" pick does the picker take all lemons from the grove. In contrast, all orange picking activities are "strip" picks. Further intensifying the difficulties of picking lemons relative to oranges is the fact that lemon trees have thorns and are generally bushier than orange trees. In fact, lemon pickers typically wear rather heavy clothing and shoulder-length, rather awkward looking gloves in order to protect their persons from the thorns. Many individuals specialize in lemoa-picking and will pick oranges only when there are no lemons available; whereas relatively few people who primarily pick oranges will pick lemons in the absence of oranges.[4]

Apart from the dcgree of difficulty of the picking operation, the actual mechanics of picking of the two types of fruit appear to be identical. Citrus groves in southern California are universally planted in long, straight rows so as to fdcilitote irrigation, maintenance, and harvesting activities. Upon the arrival of pickers in the grove, the grove is divided according to "drive" rows down which a collection device (e.g., a truck) periodically makes an appearance. Individual pickers are then assigned row sets of three. trees on both sides of the drive row. Each picker is usually initially assigned the same six rows with which to initiate his picking activities at each new grove. The ease of the pick for the first row set thus varies randomly from grove to grove for each picker. Only this first row set is assigned. After the initial assignment, the pickers leapfrog, although unless there are only a small number of rows remaining, once a picker starts a row it is his to complete. In cases where the number of remaining rows is inadequate for a one-to-one correspondence between pickers and rows, everyone picks what remains.[5] These procedures appear to vary not at all among groves.

Citrus pickers are paid on a piece-rate basis; that is, each picker is paid a unit price for the quantity of fruit he picks rather than the number of time units he expends. The relative ease of picking therefore helps to explain the quantity of fruit he picks and the amount of money he earns for any given time interval during which he picks. Seamount and Opitz (1974) disaggregate the picking activity into three facets: net picking time; time moving within and between trees while picking; and time moving to and from field containers and dumping fruit into these containers. The proportion of time passed in each of these three facets will vary according to whether the picker is engaged in skirt or ladder picking. Ladders are used with trees the fruit of which cannot be reached with both feet on the ground. Ladder picking is thought to slow the picker's rate of pick by forty to sixty percent relative to skirt picking.[6]

Net picking time is the picking act of searching, reaching, clipping,' and placing the fruit in the bag the picker has hanging diagonally across his shoulders and carries on his hip. For ladder strip picks, it accounts for sixty percent or more of the picker's time and more than five minutes per standard 3115 cubic inch field box.' Seamount and Opitz (1974, p. 165) list the following nonpicker factors as probably influencing net picking time: fruit density; distance of the fruit from the picker; fruit size; fruit stem characteristics; tree leafiness; picker orientation; piatform stability; freedom of various picker body members; portion of the tree being picked ; and tree height , diameter, nnd surface characteristics.

Frequency of movement within and between trees is though to be related to fruit density, fruit clustering, and ease of reaching the fruit.[8] The trees in most citrus groves are planted sufficiently close together so that movement between trees is thought to have little or no influence on rate of pick. The speed with which others in the picker's crew pick could have some influence on the individual picker's rate of pick since it can influence the distance he has to move among row sets. However, movenrcnt from one row set to another by a single picker is sufficiently infrequent to make it implausible that the factor has other than trivial importance to the rate of pick. For strip picking with ladders and for an extremely small sample of pickers' time moving within and between trees an average of about one and one-half minutes per 3115 cubic inches in box of fruit is required.[9]

Transporting the picked fruit from the row sets to field receptacles placed in the drive rows and dumping the fruit into these receptacles consumes an average of about forty seconds per 3115 field box for most pickers.[10] Little other than the roughness of the terrain is thought to influence this facet of picking activity. Movement from one grove to another is thought by Seamount and Opitz (1974, p. 169) to be a greater influence.

In most respects, the citrus picking endeavor is ideally suited to application of the piece-work wage rate. Output is readily defined, measured, and monitored, the results of each picker's efforts are separable from those of other pickers, and the difficulty of the worker differentiating his task from the tasks of other pickers (thus making it hard for him to argue that his task is in some sense "more difficult") all serve to make it easy to assign the entire responsibility for perfunctory work performance solely to the individual picker himself.

Grove factors are, of course, likely to be the major influence upon differences In the individual picker's rate-of-pick from one time period to another. However, it should be noted that the responses of individual pickers to these factors can differ greatly from one picker to another. Thus, one must be extremely cautious, in trying to generalize from the responses of a few pickers to the entire picker population. This caution is well supported by some of the findings of Smith, et. al. (1965), with respect to lemon pickers. While studying an "example" crew, they noted that the fastest worker picked an average of 3.375 field boxes per hour while the slowest picked only 1.750 field boxes per hour. The crew mean was 2.570 boxes per hour with a standard deviation of $\pm$ 0.389 boxes per hour.[11] In a separate sample of 2500 pickers only 24 percent of the total variance in rate of pick could be accounted for by grove factors, while 64 percent was accounted for by variations in pickers.[12] They also note that variations in rate-of-pi.ck appear to be much greater among U.S. citizens than among the Mexican nationals working in identical groves-[13]

The Wage System. As earlier noted, citrus pickers are paid by the quantity of fruit they pick rather than by the number of hours they work. Pickers having two or three months of experience who are unable to earn the minimum wage regularly are simply terminated.[14] Three different classes of means of determining the piece-work wage rate for a particular grove on a given day appear to prevail. Two of the three are, in effect, sequential spot contract systems in which the picker and his employer are continually renegotiating on terms that must be satisfactory to picker and to grower. The three classes may be distinguished according to the extent to which and the manner in which the factors that contribute to the difficulty of picking are taken into account.

The most sophisticated means of determining piece-work wage rates per box of fruit picked is employed for lemons. This means is simply a component of a labor management system designed to reduce rates of picker turnover and absenteeism and thereby lower grower screening and recruiting costs for pickers as well as reducing the likelihood of having to reallocate inputs because of the unexpected absence of a picker. Unless the grower has available a perfect substitute at equivalent cost, each picker who quits or each day a picker is absent means that the grower must, at a cost, attempt to adjust either by juggling the distribution of tasks among the remaining workers or by initially hiring more workers than the picking process requires in order to ensure duplication of the services of absent or terminated pickers. The motivation is to do away with the historically casual nature of the supply of pickers to lemon growers. In order to enhance the likelihood of assuring themselves a reasonably stable labor supply of more-or-less known quality, the lemon growers have tacitly shifted part of the risk of the picker's uncertain income stream and living conditions to themselves; that is, by providing health, disability, unemployment, and life insurance, retirement plans, explicitly stated promotional tracks, paid vacations, and other accoutrements of the modern industrial blue or white collar worker, the growers have to some degree transferred many risks that historically have accrued to the picker to the income streams of the growers and their creditors.[15]

One major means California lemon growers have adopted to unburden the picker of variability in his income stream is to adjust piece-work wage rates in accordance with the degree of difficulty in picking conditions.

The more difficult the picking chance, the higher the piece-work wage rate. For lemon pickers, the wage per box of fruit picked associated with each combination of three key grove variables that supposedly influence the rate of pick are published and are applicable for several weeks or perhaps an entire season. Table 2.2 presents a pay schedule used in Ventura County during the middle 1960's. The pay schedules relevant to lemon picking in the current study are identical in structure, although the piece-work wage rates have been altered over time.

As Table 2.2 indicates, the supposedly influential variables are the number of fruit on the tree that meet the specified conditions (e.g., color), size of fruit, and tree height. The values of these variables are recorded at the time of picking for each grove in which the picker's crew works.

Since all fruit meeting prespecified conditions is to be picked. a picker's earnings in any particular grove are then the number of boxes of fruit he picks multiplied by the per box wage rate as determined by the fruit density, fruit size and tree height in the grove. It should be noted, however, that these three grove variables do not always completely determine the per box wage rate, for they do not capture all grove attributes thought to contribute to the relative difficulty of picking. For example, as mentioned elsewhere, the slope of the ground in the grove and the bushiness of the tree are also influential. In groves where variables in addition to the three variables mentioned above are thought to be relevant, the foreman of the picker crew apparently announces the adjustment before the picking performance. Moreover, since all fruit meeting prespecified conditions is to be picked, pickers have little, if any, incentive on a particular day to urge each other to slow the rate of pick, given that all pickers are at least earning the minimum wage. To do so would reduce the earnings of the better Pickers without enhancing the earnings or reducing the required work effort of the slower pidkers. Of course, the schedule of the per box wage rates with respect to a particular grove variable might be adjusted over time if it became Particularly noticeable that certain pickers were receiving earnings greatly in excess of what might normally be expected. This adjustment might redound to the disadvantage of those pickers whose performance was not so responsive to variations in the variable in question. It is then conceivable that the latter pickers might urge the former

Table 2.2

Rates of Pay in Cents per Box for Lemon Picking, by Tree Classes, Yields, and Fruit Size, Ventura County, 1964.

Yield	Class I*			Class II			Class III			Class IV		
	Fruit size (number per box)											
	Under 240	240-300	Over 300	Under 240	240-300	Over 300	Under 240	240-300	Over 300	Under 240	240-300	Over 300
bxs/tree**	cents											
0-1/4	47	56	70	57	64	75	66	72	79	78	86	95
1/4-1/2	41	46	53	48	54	59	55	60	66	67	73	81
1/2-3/4	36	40	45	42	46	51	47	51	56	58	63	70
3/4-1	33	37	41	38	42	45	42	46	50	52	56	62
1-1 1/2	31	33	36	35	38	41	38	41	44	47	51	54
1 1/2-2	29	31	33	32	35	37	34	37	41	43	46	50
2-3				30	32	35	31	34	38	38	42	46
3+							28	32	36	35	39	43

*Tree classification:
- Class I - Picked without a ladder.
- Class II - Ladder-picked trees less than 9 1/2 feet tall.
- Class III - Ladder-picked trees 9 1/2 to 12 feet tall.
- Class IV - Ladder-picked trees over 12 feet tall.

**Field box capacity: 2,926 cubic inches.

Source: Smith, et. al. (1965, p. 6).

pickers to reduce their performances. Nevertheless, since there are several thousand pickers employed in any one crop season,[16] it does not seem far-fetched to view the picker as a wage-taker; that is, he acts as if his picking performance does not influence the per box wage rate he will receive and, furthermore, other pickers act as if he does not influence the per box wage rate they receive.

The second class of means of determining the piece-work wage rate is considerably less formal. It is what is in effect a sequential spot contracting system found in orange harvest efforts where the grove variables likely to influence picking performance differ from one grove to another. Even for those crews who, when picking lemons, work under, a published fee schedule that matches wage rates to combinations of picking conditions; the per box wage rate applicable to a particular orange grove is only determined shortly before the entrance of the crew into the grove. Upon the discovery that the prior determination of the wage rate does not accurately reflect picking conditions, this wage rate may be adjusted. However, at least for the crews for whom we collected data, the wage-rate was never reduced after entrance to the grove. It was only increased and then only infrequently.

Finally, for sets of groves that are extremely uniform in quality and for which pickers will therefore be picking for extended periods of time under more-or-less uniform conditions, piece-work wage rates are established only in accordance with the labor supply and demand conditions prevailing at the beginning of the season or picking period. This, of course, raises the possibility that faster workers may be urged by their slower fellows to reduce their picking rates so as to reduce the possibility of management demands to raise average performance levels. Management is undoubtedly aware of these group pressures but, to judge from the pay system they have adopted, it apparently feels that the cost of the loss in picker productivity is outweighed by the cost reductions due to not having to keep detailed picker Performance and grove attribute records when groves do have uniform attributes. In any case, for the data we possess, it is only in the Irvine area where this could constitute an analytical problem,

<u>A Review Of the Salient Features</u>. Since the purpose of this study is to estimate the response of the citrus picker's work performance to variations in air Pollution, an analytical model of the picker's decision problem is

required in order to generate testable hypotheses. Most important, the model must be a reasonable representation of reality. From the discussion of the preceeding pages, the following salient features of the market for citrus picking labor can be culled. It is desirable to account for these features in any model of the picker's decision problem.

1) At least on the supply side, the market for citrus pickers embodies the major feature of a competitive labor market, i.e., the individual picker is a wage-taker.

2) The picker is paid entirely on a piece-work basis.

3) Entry into the market is easy. Exit appears to be even easier.

4) The market has substantial geographical and numerical scope.

5) Citrus picking, at least for any single variety, is a homogeneous activity for which individual pickers cannot differentiate their particular tasks from those of other pickers.

6) The citrus harvest is a highly labor-intensive activity. Except for ladders, cutting shears, and bags into which to deposit picked fruit, complementary capital inputs exercise little, if any, influence on the individual picker's output. Moreover, there are no good economic or even technical substitutes for" the individual picker'.

7) Market price-of citrus fruit is not a primary influence on the quantity and temporal distribution of harvest labor requirements within a single harvest season.

8) The picker's output is readily defined, measured, and monitored.

9) Picking procedures are standardized from one grove to another.

10) While picking a particular grove, picking procedures do not require the picker to take involuntary leisure.

11) Each picker's efforts are separable from those of other pickers.

12) A learning curve of two or three months duration exists for picking citrus fruit.

13) Substantial differences are known to exist among pickers in the responses of their picking rates to certain grove attributes.

14) The citrus picker's immediate supervisor, the picking crew foreman, is typically paid on the basis of the quantity of fruit his crew picks per unit time.

15) A salaried field superintendent from a growers' cooperative or a packing-house oversees the crew foreman.

16) For given labor market conditions, piece-work wage rates vary with the degree of picking difficulty in a particular grove.

17) The piece-work wage rate is set by the crew foreman or field superintendent before initiation of picking activity in a particular grove. However, this wage rate may later be modified If initial expectations about picking conditions are not fulfilled.

18) During a particular harvest season, the individual grower is a price-taker for both his fruit crop and his use of harvest labor.

Footnotes: Chapter 2

1. In a study of family and hired labor on U.S. farms, Sellers (1966, p. 35) states, in effect, that all commercialcitrus growers employ hired labor.

2. See Bell (1965, p. 4).

3. Interview of the first author with Mr. Robert Lamberson and Mr. Edward Ruiz of Upland Lemon Growers, March 11, 1976.

4. Interview of the first author on March 12, 1976, with Mr. Xavier Piedra, Manager of the San Gabriel Valley Labor Association.

5. The description in this paragraph is a synthesis of conversations of the first author with Mssrs. Lamberson, Ruiz, and Piedra, as well as Mr. Mack Garcia of the River Growers Association in East Highlands, California.

6. Seamount and Opitz (1974, p. 165).

7. Ibid.

8. Ibid., p. 167.

9. Ibid.

10. Ibid.

11. Smith, et. al. (1965, p. 20).

12. Ibid., p. 36.

13. Ibid., p. 23.

14. Smith, et. al. (1965, pp. 46-51) state that this occurs. Interviews of one of the authors with labor camp managers confirmed the Smith, et. al. statement.

15. See Manpower Administration (1969) and Rosedale and Mamer (1974) for detailed descriptions of the features of the system. The description offered in the latter source which, among other things, refers to special leaves, birthday greetings and cake, counseling, and legal aid, Christmas greetings, adult education, and entertainment, is reminiscent of newspaper accounts of the Japanese firm or perhaps an academic cnvironmcnt. Mr. Jack Lloyd of the Coastal Growers Association in Ventura County is widely credited with developing the system. Insights into the motivations for developing the system are available in Smith, et. al. (1965, pp. 14-19). A study of the variability of the degree of risk-shifting

from pickers to growers with respect to such factors as the productivity and dependability of the picker, the market for lemons, societally provided benefits, labor supply, and other factors would be most interesting. At the abstract level, a framework for approaching these questions is to be found in Alchian and Demsetz (1972) and Crocker (1973). A much more thorough development is presented in Azariadis (1975).

16. Rosedale and Mamer (1974, p. 19) state that in 1973, 3335 pickers were employed by the Coastal Growers Association of Ventura County alone.

Chapter 3

THE DATA BASE

Description. Two classes of data make up the empirical basis of this study: (1) observations on indicators of picker work performance such as boxes of fruit picked and hours worked; and (2) observations on the conditions under which the picker worked such as the piece-work wage rate and grove and environmental conditions. These two data classes are available on no less than a day-to-day basis for each individual picker studied. Air pollution and temperature data are usually available on an hour-by-hour basis. Since no systematic effort was made to collect data on individual picker characteristics such as age and state of health, no comparisons across individuals of the reasons for variations in work performance are possible.

Except for the air pollution and temperature observations, all data were acquired from records maintained by citrus packing-houses and labor camps in southern California. These packing-houses and labor camps were selected from a list supplied by Sunkist Growers Cooperative. Every packing-house and labor camp on the list was sent a copy of the original research proposal along with a letter explaining the type of data in which we were interested. The various packing-houses and labor camps were then contacted by telephone in order to ascertain their willingness to cooperate in the study and the nature of the data they possessed. The following criteria were developed for the collection of data from the packing-houses and labor camps during the summer of 1975. It should be recognized that the application of these criteria resulted in a nonrandom sampling of the citrus picker population.

1) The study is a panel study in which the objects of interest are the daily work performances of individual citrus pickers. Data files containing detailed information on the day-to-day work performances and conditions of individual pickers are therefore to be sought.

This perspective of the central objective of the study avoided the necessity of collecting possibly sensitive data on individual picker socioeconomic attributes such as age, state of health, etc. Each individual worker selected for study can then be treated as a separate and distinct study.

2) Most of the individual pickers for whom work performance and conditions data are acquired must have worked at times and locations where ambient concentrations of photochemical smog were substantially above background levels. Given that the central objective of the study is to ascertain the covariation of picker work performance and photochemical smog the rationale for this criterion is obvious.

3) Pickers are to be selected having near continuous records of employment as citrus harvesters during 1973 and 1974. The years 1973 and 1974 were selected because citrus growing conditions, according to packing-house managers, exhibited substantial differences between the years. Moreover, the most detailed ambient smog data was available for these years. Pickers with long employment histories during the two-year period were desired in order to maximize available degrees of freedom for hypothesis testing.

4) Pickers are to be selected having at least one year of experience in citrus harvesting. It is hoped that the application of this criterion negated any of the learning effects to which Smith, et. al. (1965, pp. 41-46), refer.

5) Pickers having relatively high, moderate, and low records of average daily earnings are to be selected, Although there was no intent in the study to make detailed explanatory comparisons of work performance among pickers, it was thought desirable that a set of pickers having a fair distribution of apparent potential productivities be selected. The reason was an intuition that the influence of air pollution upon picker performance might vary with the potential productivity of the picker.

In Table 3.1 is provided a listing of al.1 picker performance and grove condition data obtained for 237 individuals, with 103 individuals from Upland (U) and Riverside (R) , 60 individuals from Ventura (V) , 32 individuals from Irvine (I) , and 42 individuals from San Bernardino-Redlands (S) .[1]

Temperature and air pollution data consist of records of a number of monitoring stations throughout southern California. These records are maintained on computer tape by the Statewide Air Pollution Research Center of the University of California , Riverside. Table 3.2 provides those temperature and air pollution monitoring stations by name that were used

Table 3.1

Individual Picker Performance and Grove Condition Data

A. Data Organized by Crew to which Individual Picker Belongs.

Data Description	Unit of Measure	Location
Calendar date	Day	U,V,S,I,R
Grove location	1/4 Section	U,V,S,I,R
Camp departure	Military time	U,S,R
Camp return	Military time	U,S,R
Picking initiated	Military time	U,S,I,R
Picking terminated	Military time	U,S,I,R
Wage rate	Cents per 3115 $in.^3$ box	U,V,S,I,R
Fruit type	Lemons, navels, valencias	U,V,S,I,R
Fruit size	Fruit per 3115 $in.^3$ box	U,V,I
Tree class	Height in feet	U,V
Average boxes picked per tree by crew	3115 $in.^3$ boxes	U,V,S,I,R
Total trees picked by crew	Trees	U,V,I
Tree age	Years	S

B. Data Organized by Individual Picker.

Data Description	Unit of Measure	Location
Work time	Hours	U,V,S,I,R
Boxes picked	3115 $in.^3$ boxes	U,V,S,I,R
Refused to work	(0,1)	U
Sick, did not work	(0,1)	U
No reason, did not work	(0,1)	U
Nonpicking work activity	Hours	U,V,S,I,R
Weekly gross income	Cents	U,V,S,I,R
Weekly net income	Cents	U,V,S,I,R
Lives in labor-camp	(0,1)	U,V,S,I,R

Table 3.2

Temperature and Pollution Stations

Grove Locations	Temperature Station Name	Pollution Station Name
Upland	Upland	Upland Civic Center
Ventura	Santa Paula (1973) Summit Fire Lookout (1974)	Santa Paula
San Bernardino-Redlands	San Bernardino	San Bernardino
Irvine	El Toro Air Station	El Toro
Riverside	UC, Riverside	Norco

for each of the general grove locations. All temperatures used in this study are maximum hourly arithmetic average dry-bulb temperatures in F^{o} on each work-day of interest. Air pollution measures are hour-by-hour arithmetic averages of ambient concentrations of ozone or oxidants in parts per million by volume.

Possible Sources of Measurement Error. Known as well as suspected measurement errors lurk throughout the data set used for this study. Some are perhaps sufficiently severe to intrcduce serious possibilities of bias into empirical estimates of relationships developed from the analytical framework of the next chapter.

Given the objective of this study, by far the most unkind source of measurement error is the air pollution data. The following quote, in a December 18, 1975, memorandum entitled Errors in Ozone/Oxidant Monitoring Systems from Mr. Roger Strelow, Assistant Administrator for Air and Waste Management, USEPA, to all USEPA regional administrators, succinctly states the most dismaying facet of the problem with the air pollution data,

> "Based upon results to date, we suspect that the existing data could possibly contain some positive and some negative errors... Therefore, I do not believe we should attempt to make any modification6 to the existing data; we simply do not know what adjustments to make, or even if the data is generally too high or too low." (p. 3)

Earlier in the memorandum, Mr. Strelow notes that certain combination6 of instrumentation, calibration procedure, and operator performance appear to result in a variable negative bias.

The above does not exhaust the sources of error in the air pollution data. With the exception of the air pollution and temperature monitoring stations relevant to the fruit harvesting sites in Irvine and Ventura, all monitoring stations are generally located five to eight miles from the groves. In both Irvine and Ventura, the monitoring stations are central to and only a short distance from all picking sites. However, in Upland, San Bernardino-Redlands, and Riverside the stations are in downtown areas and are typically at somewhat lower elcvntions than in the groves. The locations of these stations relative to the groves made it impossible, by triangulating among stations, to arrive at a weighted mean of harvest site air pollution concentrations and temperatures. Instead, the temperature and the concentration at the monitoring stations closest to the harvest site have in all cases been used as a measure of the temperature and air pollution at the harvest site. We have absolutely no basis for judging discrepancies in measures realized at the stations and the actual measures at the harvest site. If a guess is required we would assert, on no basis other than casual observation, that readings at the Upland, San Bernardino-Redlands, and Riverside stations were slightly higher for some'hours on some days more frequently than they were slightly lower than the actual state of affairs in the groves. This assertion is made on the basis of the downtown locations and lower elevations of the monitoring stations; it is not an assertion we are anxious to defend.

Relative to the measurement errors in the environmental conditions data, sources of this error in the grove conditions and work performance data seem innocuous and limited indeed. Perhaps the most serious is the rounding-off of the number of hours a picker has worked to the nearest half-hour. In circumstances where the work-day has been rather short, this could lead to some bias in estimates, although it seems likely that there is no systematic bias with respect to the sign of the error.

It is possible that error exists in the size-of-fruit variable, when observations on this variable are available. Typically, the daily value for this variable-is determined by having the foreman of the picking crew select five boxes of fruit harvested that day from the grove being picked. The total number of fruit in the boxes divided by five then represents the "size-of-fruit" recorded for determining the piece-work rate of pay. Although an effort is apparently made to select individual boxes from a number of locations within a particular grove, a sample of five boxes from the dally population of several hundred boxes a crew is likely to pick is at best a "small" sample; that is, it will probably be biased. We possess no information, however, permitting us to evaluate the direction or the magnitude of this possible bias.

Other than the instances referred to in this section we arc unaware of any other possible sources of measurement error in the data we have used.

Footnotes: Chapter 3

1. Worker performance data were obtained from the San Gabriel Valley Labor Association of Cucumonga, the Lemoneira Ranch of Santa Paula, the River Growers Association of East Highlands, and Irvine Vnlencia Growers of Irvine. Grove condition data were provided from Upland Lemon Growers of Upland, Lemoneira Ranch of Santa Paula, Western Fruit Growers Packing Company of Plentone, Irvine Valencia Growers of Irvine, and Corona College Heights Citrus Company of Riverside.

Chapter 4

A MODEL OF THE HARVEST OPERATION

Our fundamental purpose is to explain the influence, if any, that photochemical smog has upon the work performance of the individual citrus worker. It is obvious that any attempt to establish empirical values for this influence requires that the expressions to be estimated be explicitly derived from an analytical statement of the picker's decision problem. It is perhaps not so obvious that a complete analytical statement of the picker's work performance requires some attention to the grower's decision problem. The reason is that the picker's work performance is influenced by certain of the choices the grower makes. In turn, these grower choices are plausibly influenced in part by the grower's past observations on picker work performance. Thus, at least initially, one must recognize the interdependent nature of the two sets of parties' decision problems. Only then can one legitimately consider making a set of assumptions that will form the basis of the analytical model to be estimated. Sound judgment of the value of what is ultimately retained relative to what has been cast aside requires knowledge of the scope of this initial problem framework.

As noted in Chapter 2, with or without the intermediation of a labor contractor or a grower cooperative, the picker-grower relationship can be described as a sequence of spot contracts. The individual citrus picker is an independent contractor who daily sells his labor services in response to various combinations of piece-work wage offers, expected picking and environmental conditions, and prospective hours of work. The product the picker is selling is the number of boxes of fruit he picks within a given time Interval. His realized daily earnings are determined by his wage per box of fruit picked, the relative ease of picking the fruit, and the number of hours he is able to' work. The relative ease of picking the fruit may plausibly influence his innate productivity as Well as the number of hours he chooses to work. In either case, his realized earnings will be affected.

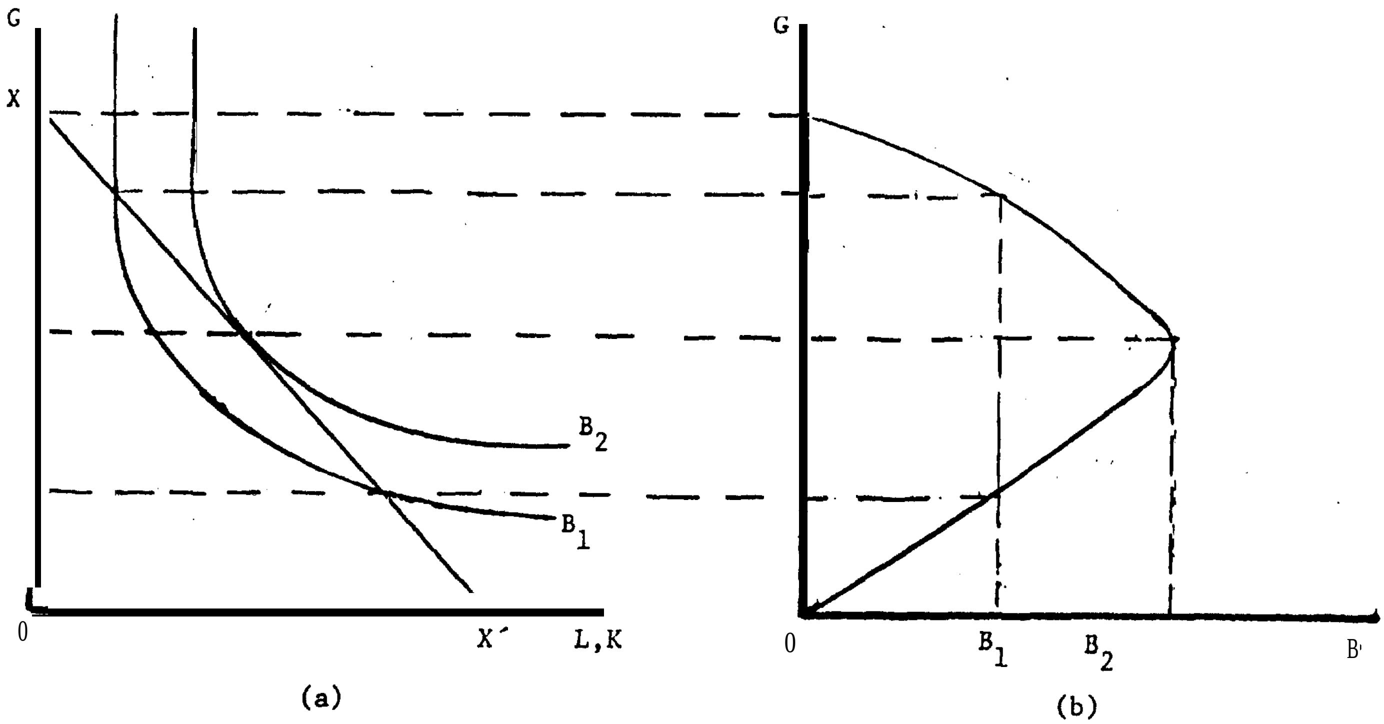
Just as pickers can trade-off reduced effort and gains in income, so can growers substitute between fruit output and those grove conditions that enhance the ease of picking. Of course, fruit output and certain grove conditions (e.g., fruit density) that enhance picking are highly complementary. However, other grower investment activities increase grower costs without contributing anything to and perhaps even detracting from the amount of fruit grown. For example, growers can reduce the height of their trees or clear the ground of large stones so as to aid picking ease. In the extreme, a grower might remove any tree from his grove once it reaches a height requiring a ladder to pick its fruit. Younger and shorter trees yield less fruit, however. If the grower reduces his fruit output in order to make life easier for the pickers, he often reduces his gross revenues ; but if he increases his fruit output in order to increase his gross revenues, he sometimes makes life harder for pickers. Making life harder for pickers requires, if they are to be willing to accept the harder life, that the grower increase his costs by increasing the piece-work wage rate for picking.

Figures 1a and 1b below present the non-pecuniary essence of the grower's <u>long-term</u> problem. In Figure 1a, the B-isoquants represent output levels embodied in the citrus fruit production function. The citrus fruit that will be hanging on the trees is influenced by the <u>non-harvest</u> labor and capital, L and K applied to the grove, and the composite grove conditions, G. G is an output as well as an input; that is, it is a product the grower sells to the picker in exchange for reduced piece-work wage rates as well as being a determinant of fruit yields. Now, viewing G as an output rather than an input, the line XX' shows, for a given stock of fully employed L and K, the relation between composite grove conditions developed solely to ease picking and non-harvest labor and capital devoted to improving fruit yields. Alternatively, the X'-intercept can be taken as the origin. The labor and capital devoted to producing grove conditions rather than fruit yields increases as one moves to the left from the X--intercept. Thus, when the X*-intercept is taken as the origin, the XX' line simply indicates the ratio of G to the amount of L, K committed to the production of G.

Figure 1b is derived, as indicated by the dotted lines, from the intersections of the isoquants in Figure 1a with XX'. Over the OB_2 interval on the B-axis of Figure 1b, an improvement in grove conditions

Figure 4.1

Relationship Between Grove Conditions and Fruit Yields



occurs jointly with an increase in fruit yields. For example, the careful pruning of trees will both increase.hanging fruit and make the harvesting of fruit easier. The OB_2 interval of Figure lb corresponds to a movement from X' to the tangency of B_2 with XX' in Figure la. If, from the grower's perspective, both fruit output and grove conditions command positive prices (the first by increasing gross revenues and the second by reducing the harvest costs), the grower will never intentionally select a combination of fruit output and grove conditions in'the increasing portion of the production possibility frontier in Figure lb. He will instead select a portion in the declining portion of this boundary because it is only in this portion that the grower, in order to increase his revenues.by producing more fruit, must at the same time increase his harvest costs by making picking more difficult .

The implications of Figure 4.1 are unnecessarily complex for this study. Little, if any, violence is done to the nature of the grower's decision problem if the harvest problem is treated as being entirely separable from decisions about investing in grove conditions and fruit yields, From the 'perspective of the current harvest, all prior investments are predetermined. Moreover, except for extreme circumstances where one decides to harvest the fruit by bulldozing the trees, current harvest decisions have little or no effect upon future fruit yields or grove conditions. Assuming all growers to be net revenue maximizers, the representative grower's harvest (i.e., short-run) decision problem can therefore be represented as:

(1) $\text{Max: } \pi = pB - bK - vL - C$,

where :

(2) $B = B(C)$, a concave function, and $B_C \geq 0$,

and

(3) $C = C(w,K,L,\bar{G},\bar{E})$, $C_K, C_L \geq 0$; $C_w \gtrless 0$.

A subscript indicates a derivative taken with respect to the subscript, and

π is the grower's net ruvenue from the harvest.

p is the constant daily selling price of a box of fruit.

B is the number of boxes of fruit actually picked by a picking crew,

b is the unit rental price of composite capital.

K is the number of units of composite capital the grower employs.

v is the hourly wage rate of nonpicking labor.

L is the man-hours of nonpicking labor.

w is the. wage the individual picker receives for each box of fruit he picks.

C is the grower's expected total wage bill for pickers. It is thus the piece-work wage rate multiplied by the number of boxes of fruit the grower expects to have picked. Consistent with the static statement of the nature of the grower's harvest decision problem, the speed with which picking occurs and thus the number of workers he hires are presumed to be matters of indifference.

$\bar{G}$ is an invariant, composite variable representing existing grove conditions that influence the ease of picking. In a longer-run setting, it would be a function of nonpicking labor; capital, and environment, and their respective prices. It includes the quantity of fruit hanging on the grower's trees.

$\bar{E}$ is a composite variable representing environmental conditions such as air temperature and photochemical smog concentrations that may influence the ease of picking. It is exogenous to the grower.

Expression (2) states that the number of boxes of mature fruit the grower will have picked is a function of the total picker wage bill the grower expects to have to pay. As (3) indicates, this total picker wage bill depends upon the piece-work wage rate, grove and environmental conditions, and the quantity of nonpicking labor and capital provided that it is complementary to picking labor. It appears in practice, however, that the provision of non-harvest labor and capital differs only trivally from one grove to another. We therefore disregard it in subsequent discussion.

Upon substituting (2) and then (3) into (1), and partially differentiating the result with respect to w, K, and L, one obtains the usual first-order conditions. These conditions determine the net revenue maximizing values $w,^*$ $K,^*$ and L^* for the grower in terms of p, b, and v as well as the parameters of $B(\cdot)$ and $C(\cdot)$. One of the conditions:

(4) $\pi_w = pB_cC_w - C_w = 0,$

or

(4a) $p = B_c^{-1} = CB$

is a standard result. This expression states that short-run grower net revenue maximization requires the marginal cost of fruit picking, C_B, to be set equal to the selling price of a box of picked fruit.

The value of w the grower chooses constitutes part of the picker's decision problem. The daily decision problem the picker faces may be. stated as:

(5) Max: $U(I_t, H) \qquad U_{I_t} > 0,\ U_H < 0$

subject to:

(6) $I_t - w(G) \cdot B\,(E, G, H^+ - Z) + M = 0$

(7) $H(E, G, I_{t-1}) + Z = H^+$

where $U(.)$ is concave, all partial derivatives are continuous, and where:

I_t is the picker's daily consumption expenditures and savings. For notational simplicity, it is assumed the picker works in only 'one grove a day.

H is the daily number of hours the picker harvests fruit in a particular grove.

H^+ is the length of the picking crew's work-day in a particular grove. The individual picker is unable to influence the length of this work-day.

I_{t-1} is the picker's earnings in the previous pay period.

Z is the leisure time the picker voluntarily takes when he otherwise could have been working.

M is all nonpicking income accruing to the picker.

All other variables are defined as they were for the grower.

This formulation of the picker's short-run decision problem states that he obtains utility, U, from income (or the physical goods and services that income can buy) and that he receives disutility from work. Utility for each day directly depends only on the level of earnings and the hours of work during that day, although the hours of work may be influenced by earnings in the previous pay period. The incentive effects, if any, of income and social security taxes and minimum wages are disregarded.[1]

The first constraint, (6), implies that the picker's daily consumption expenditures and savings are exactly equal to his daily earnings from harvesting citrus plus whatever outside income he is able to obtain. Outside income, M, is fixed for the day in question. The second constraint implies that the . daily number of hours the worker is able to pick cannot exceed the number of hours that the crew to which he belongs picks. Time during which his crew picks but the worker does not pick is used by the worker to pursue leisure activities from which he obtains positive utility.

Since the picker is unable to influence the length of the crew's work-day, the above decision problem may be written as:

(8) $L = U(I_t, H) - \lambda\,[I_t - w(G)\cdot B\,[E,G,H(.)] + M] = 0$

and the necessary conditions for an interior utility maximum are:

(9) $L_{I_t} = U_{I_t} - \lambda = 0$

(10) $L_H = U_H - \lambda w B_H = 0$

(11) $L_\lambda = I_t - w(.)\cdot B\,[E,G,H(.)] + M = 0$

Expressions (9) and (10) above represent, respectively, the marginal utility of earnings and the marginal disutility of work presuming that the opportunity to acquire earnings by working exists. Taken together, (9) and (10) imply

(12) $U_H/U_{I_t} = \frac{\lambda w B_H}{\lambda} \equiv wB_H$,

which is the value of work to the picker and the rate at which in equilibrium he is willing to substitute leisure for earnings. From (4) and (12), simultaneous individual grower net revenue and individual picker utility maximization thus requires that:

(13) $CB = wB_H$;

that is, the rate at which the grower's expected total wage bill changes in response to changes in boxes picked must be equal to the value of work to the picker.

From the individual picker's perspective, the left-hand side of (13) is predetermined. Although this picker may have some trivial influence upon CB, the thousands of citrus pickers available to growers in southern California make it worthwhile for the individual picker to behave as if he hod no influence what soever. Each day the picker is considering whether or not to work therefore, the picking opportunities available to him are composed of a set of discrete points, one point for each grower, where the coordinates of a point indicate the total earnings a picker can expect to be paid by a grower in exchange for picking fruit over a work-day of given length.

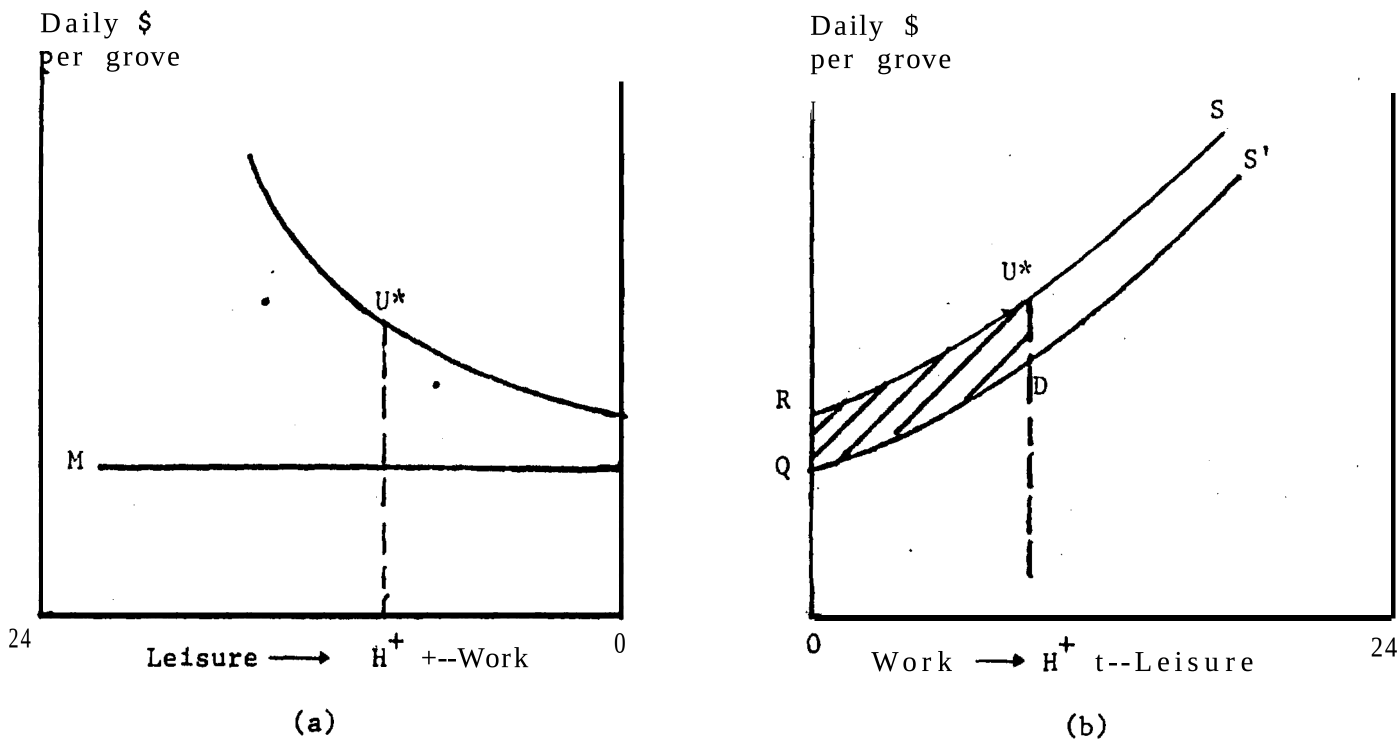
Temporarily assume that all growers are identical in terms of their grove attributes, except that their groves differ in size and therefore fequire a greater expenditure of hours from a given number of men in order to be picked. This implies that the piece-work wage rate will be constant across groves and that the individual picker's earnings opportunities will differ only according to the number of hours it will take his crew to pick each grove. One can therefore construct an indifference function for the individual picker showing the change in'leisure necessary to compensate him for a marginal change in perceived earnings opportunities from picking while maintaining a constant level of utility.

At the beginning of any given day, the individual picker faces the situation depicted in Figure 4.2(a). Each point in the figure represents a picking or nonpicking earnings opportunity, one point to an opportunity. Only the points on the indifference function represent picking opportunities. All others represent other types of jobs such as fruit loading, truck driving, pruning, box repair, etc. In the situation depicted, U*, which lie's on the picking opportunity indifference function, is on the highest indifference function passing through any of these points, and this point will be the earnings opportunity the individual will choose for that day. If earnings opportunities other than picking always lie below the picking opportunity
indifference function, the individual will choose to pick each and every 24
day, given that picking opportunities are available. However, if on some days, nonpicking earnings opportunities become available that lie above the picking opportunity indifference function, the individual will take the alternative job rather than picking fruit. As for the picking opportunities, they will change from day to day as the sizes of the groves ripe for picking change. Over time therefore, one will observe the individual picking at various points on his picking opportunity indifference function.

The above reasoning is not altered by the fact that grove attributes are dissimilar across groves. This is bccousc growers adjust piece-work wage rates so that for any particular expenditure of his hours over the picking day, the individual picker is led to expect his earnings will be (nearly) equal from one grove to another. This means that as crew hours

Figure 4.2

The Individual Picker's Choice of Earnings Opportunities



increase and if the picker works as long as his crew, he expects to be sliding along the same indifference function as he moves from grove to grove. Thus, for example, all groves having the attributes associated with U* in Figure 4.2(a) are expected by the picker to provide the same level of earnings for the expenditure of H^+ hours of his time.

After subtracting nonpicking income, the S curve in Figure 4.2(b) is the mirror image of the picking opportunity indifference function in Figure 4.2(a). Since the indifference function has a negative slope throughout, the slope of the S function is the negative of the individual picker's marginal rate of substitution between earnings and leisure. It thus provides a constant real income supply function which, because of the convexity of the picking opportunity indifference function, has a positive slope. Since the S function is a compensated supply function, it has no backward bending portion as do ordinary labor supply functions. Once the individual has actually selected a grove in which to pick, the S function also represents the number of hours the picker is willing to supply the grower at different levels of earnings.

The above commentary has almost entirely concentrated upon the individual picker's decision problem at the start of each work day. However, once he has made his choice of a grove in which to pick, he may discover that his initial perceptions were mistaken. For example, assuming that his first-stage decision of whether or not to pick is not influenced by his expectations about levels of air pollution, he may find, once he has started picking, that his earnings are distressingly low because air pollutionlevels are reducing his physical picking prowess.[2] Similarly, he may find that the. piece-work wage rate being paid is imperfectly adjusted to grove attributes so that his earnings for a given time expenditure are less than he had been led to expect. These disappointments are reflected in the shift of the supply function in Figure 4.2(b) from S to S'. If in spite of his disappointments the picker continues to work as long as his crew, the cross-hatched area RQDU* represents the additional income required to return the individual to his former indifference function. It is thus a measure of the compensating surplus and is representative of the social loss caused by air pollution that attaches to this picker. However, since the picker is, by assumption, constrained to work the same number of hours as his crew, the area overstates the compensation required if he were allowed to adjust his hours downward. Upward adjustments of hours are infeasible because the picker is institutionally constrained from working longer hours than does his crew.

Without further information, economic theory does not permit prediction of the combination of hours and earnings the picker will choose for his adjustment. Nevertheless, assuming that leisure is not an inferior good for the picker, the substitution and income effects of earnings changes possess the same sign in our compensated supply function: we should observe nonincreasing hours of work as the earnings of a picker are reduced.

Footnotes: Chapter 4

1. Pickers whose earnings after a two or three month training period frequently fail to meet the minimum wage are no longer permitted to work. In the empirical work of the next chapter only pickers who have continued to pick long after the training period are analyzed.

2. The assumption that the worker's choice among groves on any particular day is independent of air pollution levels is fairly innocuous, given the more-or-less constant distribution of expected air pollution concentrations over the locale in which the picker is likely to have picking opportunities. For example, air pollution magnitudes and magnitude durations are unlikely to differ perceptibly in those areas of Upland in which citrus is grown. Expected air pollution levels might influence the picker's decision whether or not to pick at all; however, our empirical efforts do not attempt to deal with this issue.